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**Research Document 2012/118** | **Document de recherche 2012/118**

**Gulf Region** | **Région du Golfe**

# Analyses of newly molted commercial-sized male crab percentages in landings in the southwestern Gulf of St. Lawrence snow crab fishery (Area 12): Why the estimated percentages were abnormally higher in the 2009 and 2010 seasons?

# Analyses des pourcentages de mâles nouvellement mués dans les débarquements de la pêcherie du crabe des neiges (zone 12) dans le sud du golfe du Saint-Laurent : Pourquoi les pourcentages estimés étaient anormalement élevés en 2009 et 2010 ?

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ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)
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Canada

**Correct citation for this publication:**

Moriyasu, M., Biron, M., DeGrâce, P. and Hébert, M. 2012. Analyses of newly molted commercial-sized male crabs percentages in landings in the southwestern Gulf of St. Lawrence snow crab fishery (Area 12): Why the estimated percentages were abnormally higher in the 2009 and 2010 seasons?. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/118. iii + 16p.

## ABSTRACT

The percentage of newly molted crabs (soft and white crabs) in landings has been historically low, i.e., an average of 1.6% (not adjusted to landings) between 1992 and 2008, as these crabs are not marketable. However, a considerable increase in the estimated numbers of landed commercial-sized newly molted crabs was observed in 2009 (13.5%) and 2010 (10.5%) in the southern Gulf of St. Lawrence (sGSL) snow crab fisheries. These estimates, based on at-sea sampling data, did not concord with the observations reported by some participants from the fishing industry on the level of newly molted crabs in landings. These data were reviewed in more detail to better understand the source of the discrepancies. Results showed that there were discrepancies in the carapace condition categorization criteria between observers from Biorex Gaspé and Biorex Caraquet. This difference was due to the different criteria for carapace conditions used by DFO Québec and DFO Gulf (Moncton). A new protocol was implemented in 2009 by DFO Québec and Biorex Gaspé prior to the fishing season in the northern GSL snow crab fisheries and consequently a significant number of crabs with carapace condition 3 were classified as 2 by observers from Biorex Gaspé working in the sGSL fisheries. Hence, between 2008-2010 the percentages were significantly overestimated for vessels sampled by Biorex Gaspé compared to those sampled by Biorex Caraquet. The discrepancy was adverted for the 2011 fishing season as the situation was explained to observers from both groups during the observer training sessions and necessary adjustments were made. As a result, the percentage of white crab in landings was at a low level (1.1% in Area 12) in 2011.

## RÉSUMÉ

Historiquement, le pourcentage de crabe nouvellement mué (crabes mous et blancs) dans les débarquements a été bas, c'est-à-dire une moyenne de 1.6 % (non ajusté aux débarquements) entre 1992 et 2008 étant donné que ces catégories de crabe ne sont pas commercialisables. Cependant, une augmentation considérable du nombre estimé de crabe nouvellement mué de taille commerciale débarqué a été trouvée en 2009 (13.5 %) et 2010 (10.5 %) dans les pêcheries du crabe des neiges du sud du Golfe du Saint-Laurent. Ces estimations obtenues à partir de l'échantillonnage en mer ne concordaient pas avec les observations et l'expérience de quelques participants de l'industrie concernant la proportion de crabe blanc dans les débarquements. Par conséquent, ces données ont été révisées plus en détail pour mieux comprendre la source des contradictions. Les résultats ont montré qu' il y avait divergences dans les critères de catégorisation des conditions de carapace entre les observateurs de Biorex Gaspé et Biorex Caraquet. Cette différence était le résultat de différents critères utilisés pour déterminer les conditions de carapace imposées par MPO Québec et MPO Golfe (Moncton). Un nouveau protocole a été mis en œuvre en 2009 par la Région du MPO Québec et Biorex Gaspé avant la saison de pêche des pêcheries du crabe des neiges du nord du Golfe du Saint-Laurent. Par conséquent un nombre important de crabes avec carapace condition 3 ont été classifié dans la catégorie 2 par des observateurs de Biorex Gaspé qui travaillaient dans les pêcheries du sud du Golfe du Saint-Laurent. Durant 2008-2010, les pourcentages étaient donc significativement surévalués pour les navires observés par Biorex Gaspé comparé à ceux observés par Biorex Caraquet. Avant la saison de pêche 2011, ce problème a été présenté et expliqué aux observateurs des deux groupes pendant les sessions de formation des observateurs et les rajustements nécessaires ont été faits. En conséquence, le pourcentage de crabe blanc dans les débarquements a diminué à un bas niveau (1.1 % dans la zone 12) en 2011.

## 1.0. INTRODUCTION

Snow crab (*Chionoecetes opilio*) periodically shed their hard outer shell in a process called molting in order to grow and to reach sexual maturity. It takes several months to almost a year for the new carapace to harden post-molting. Soft-shelled crab is defined by shell hardness (<68 durometer units). The term white-crab is used primarily in the summer fishery of Area 19 because the newly-molted crabs have reached a relatively harder carapace than those observed during the spring fishery (Areas 12, 12E and 12F). White crab is defined by shell hardness <78 durometer units. Both soft-shell and white crab categories can include both new soft (condition 1) and clean hard-shelled crab (condition 2).

Recently molted soft-shelled male snow crabs are of low commercial value because of their low meat content and are legally discarded at-sea by harvesters. This activity results in some mortality of soft-shelled males and may reduce the recruitment to the fishery for the following years (Dufour et al. 1997). Therefore, DFO has implemented since 1990 an intensive observer sampling program onboard commercial vessels to provide a daily assessment of the percentage of newly molted (soft-shelled and/or white-shelled) crabs and the size structure of males caught in the southern Gulf of St. Lawrence (sGSL) fisheries to avoid unnecessary mortality of the resource (Hébert et al. 2011). Two types of sampling have been conducted onboard commercial fishing vessels: at-sea sampling and at-port sampling. The at-sea sampling is used to monitor the 'soft-shell protocol' in the spring fisheries of Crab Fishing Area (CFA) 12, 12E and 12F, and 'white-shell protocol' in the summer fishery of CFA-19 (Fig.1). The protocols were introduced to protect the fisheries from an increased risk of catching newly molted male crabs and subsequent discarding mortality. Originally the at-port sampling was implemented for detecting possible at-sea discarding activities of commercial size hard-shell crabs by monitoring the differences in size and carapace condition of commercial crabs between catches and landings. This information is also necessary to verify that one of the assumptions for estimating the percentage of newly molted crab at-sea is met (that only a negligible quantity of newly molted crabs is landed: Hébert et al. 1992). The port sampling occurs at sea and represents a sub-sample of the retained catch. It is not used for the soft-shell and white-shell crab protocols.

At-sea and at-port sampling data are collected by a private company employing two different groups of observers: Biorex Gaspé, conducting at-sea and at-port sampling in both northern (nGSL) and sGSL snow crab fisheries, and Biorex Caraquet, conducting at-sea and at-port sampling in the sGSL fisheries only. The observer training has been ensured on an annual basis in early spring prior to the fishing season by DFO Québec for Biorex Gaspé and DFO Gulf for Biorex Gaspé and Biorex Caraquet. Not all observers trained for snow crab sampling by Biorex Gaspé are deployed to the sGSL snow crab fisheries.

Since almost no soft shell crab has historically been found in landings, newly molted crabs hereafter mainly refer to white crabs. Historically, the percentage of newly molted crab (comprised of soft and white crabs) in landings has been low with an average of 1.6% (not adjusted to landings) between 1992 and 2008. In 2009, Hébert et al. (2010) reported there was a considerable increase in the estimated numbers of newly molted crabs landed, 13.5% and 10.5% (by numbers) of the catch landed in 2009 and 2010 in the sGSL, respectively (Fig. 2; Hébert et al. 2011). However, these estimates based on at-sea sampling data did not concord with the observations reported by some participants from the fishing industry on the level of newly molted crabs in landings. The discrepancy could be attributed to a number of factors including: different interpretations of soft-shell / white-shell crab categorization between DFO and the fishing industry, differences in the identification techniques by observers, and localized differences in the catch composition.

There was sufficient concern at the peer review meeting of February 2011 to recommend that these data be reviewed in more detail to ensure that the methods and training were consistently applied and to better understand the source of the discrepancies.

## 2.0. MATERIALS AND METHODS

### 2.1. Basic information on crab carapace conditions used for observer training

The port sampling consists of measuring a random sample of 20 male crabs from the catch, after discarding, taken from every third trap sampled on a given sampling trip (Hébert et al. 2011). Samplers also take 40 crabs from the first two traps sampled for the at-sea sampling ("measurement before discarding" in Hébert et al. 2011). As retained crabs after sorting are to be landed, at-sea samplers do not need to measure crabs at the wharf during landing, hence the rational for calling it port sampling. This method is advantageous compared to a traditional at-port sampling because the sampling is systematic and technically easier.

The following measurements were taken for both types of sampling: carapace width (CW), chela height (CH), carapace condition (CC) (Hébert et al. 2011) and hardness at the base of the right claw (Foyle et al. 1989). The hardness measurement was determined with a 2.25 kg gauge durometer (Pacific Transducer Corp.©, California, U.S.A.) on a scale of 0 to 100 units. The following additional information was also available for each sampled vessel: name of the boat, date of sampling, total quantity landed, and the name of the sampler. In Areas 12, 12E and 12F, carapace conditions 1 and 2 were categorized as newly molted crabs (Hébert et al. 2011).

DFO Gulf Region is responsible for the training of observers on an annual basis since 1990. All observers working at Biorex (Gaspé and Caraquet) must take a course on the biological characteristics, measurements and categorization techniques of snow crab. During the session, the sampling protocol and sampling guide (Appendix-1 in Hébert et al. 2012) are distributed to the participants and practical exercises were conducted on real snow crabs. Furthermore, the Snow Crab Section (Science Branch, Gulf Region) conducts annual observer data quality control during the routine data verification process.

In 2011, the annual pre-season training sessions occurred on April 5 for all observers from Biorex Gaspé, while observers from Biorex Caraquet were trained on April 7 and 14 for new and returning observers, respectively. According to the 2011 peer review meeting recommendations, the Gulf assessment biologist met with the Québec biologist responsible for the snow crab stock assessment in nGSL during the training session in Gaspé to compare/calibrate the protocol for snow crab carapace conditions. Furthermore, data received from the observer company (Biorex Gaspé and Caraquet) since 2000 were re-verified by observer and fishing vessel.

### 2.2. Analysis of newly molted crabs in landings by vessel, by observer, and by group (Biorex Gaspé and Biorex Caraquet)

The basic information (e.g. individual observer data sheet by sampler) was verified and data from each trip were sorted by origin (Biorex Gaspé and Biorex Caraquet).

The percentage of newly molted crabs in landings was estimated by the following formula:

$$P_{sw} = \left[ \sum_{i=1}^{m} \left( {}^{n_{SW_i}}\!/_{N_{C_i}} * 100 \right) \right] / m \qquad (1)$$ No adjustment to the landings

where; $P_{sw}$: average percentage of newly molted crabs in landings for the fleet not adjusted to the landings; m: total number of vessel sampled; $n_{SW_i}$: number of newly molted crabs from port sampling of the vessel i; $N_{C_i}$: total number of crab in port samples for the vessel i.

$$\overline{P_{sw}} = \left[ \sum_{i=1}^{m} \left( {}^{n_{SW_i}}\!/_{N_{C_i}} * 100 \right) * {}^{l_i}\!/_{\sum_{i=1}^{m} l_i} \right] / m \qquad (2)$$ Adjusted to the landings

where; $\overline{P_{sw}}$: average percentage of newly molted crabs in landings for the fleet adjusted to the landings, m: total number of vessel sampled; $n_{SW_i}$: number of newly molted crabs from port sampling of the vessel i; $N_{C_i}$: total number of crab in port samples for the vessel i; $l_i$: landings of vessel i, $\sum_{i=1}^{m} l_i$: total landings of vessels sampled.

These analyses were done for data collected during the last 10 years (2000-2010) in Area 12, E, F and Area 19. In addition, in-depth analysis was performed for Area 12 data that was divided into two observer groups (Biorex Gaspé and Caraquet) for the entire season and also for the first two weeks.

The data were divided into two observer groups (Biorex Gaspé and Biorex Caraquet) and the percentages of newly molted crabs in landings were compared between fleets for the whole season, and for the first two weeks of the season without distinction of fishing ground. The statistical test was performed by t-test in case the homoscedasticity of variances was met or by Mann-Whitney test in case of heteroscedacity of variances. A 95% level of significance was used in all analyses. Comparison for the first two weeks was made because it was assumed that observers could have erroneously categorized newly molted crabs (molter of the year (CC 1 and 2)) as new hard crab (terminally molted in the previous season (CC 3)) in the later period of the season. If we limit the observation period for the first two weeks, we can eliminate this factor as the difference in external feature and carapace hardness are much clearer.

## 3.0. RESULTS

### 3.1. Basic information on crab carapace conditions used for the observer training

There was no discrepancy in the basic information given by the Gulf Region staff during the observer training since 1991. As a matter of fact, it is the same biologist and technician who have been monitoring and training both groups of observers since the program was first implemented in 1990.

### 3.2. Verification of raw data

Since 2000, the total number of crabs measured annually in port sampling varied from 17,118 to 61,332 individuals (Table 1). Although there is no strict rule of fleet coverage by the two

branches of Biorex, Biorex Gaspé covers mostly the Quebec fleet and Biorex Caraquet the New Brunswick, Nova Scotia and Prince Edward Island fleets. Data sets since 2000 were verified and no error has been detected; these data had already been verified prior to the analysis each year). However, the percentage (all Area 12 fleet) of newly molted crabs showed higher levels notably in 2008, 2009 and 2010 as described by Hébert et al. (2010, 2011). The average percentage (not adjusted to landings) of newly molted crabs in landings was estimated at 3.6%, 0.3% and 1.6% between 2000 and 2007 for Biorex Gaspé, Biorex Caraquet and combined, respectively. Whereas, the average percentage (not adjusted to landings) for the last three years (2008-2010) was estimated at 21.9%, 2.4% and 10.3% for Biorex Gaspé, Biorex Caraquet and combined, respectively. In addition the percentage (adjusted to landings) of newly molted crab between the two observer groups showed a continuous discrepancy (Fig. 3) since 2000 with more important differences in the past three seasons. Furthermore, the results showed that the recent increase in percentage of newly molted crabs in landings per fishing area/unit showed the same tendency in Areas E and F, but not in Area 18, 25/26 and 19 (Figs. 4, 5). Based on these results, more detailed analyses between these two groups (Biorex Gaspé and Biorex Caraquet) were needed.

### 3.3. Verification of sampling methods between DFO Québec and Gulf Regions

During the 2011 observer training session with Biorex Gaspé, a difference in categorization of snow crab carapace condition was found between the Quebec and Gulf Regions (Table 2). Although identical carapace condition characterization was done in the past between the two Regions, a new system was introduced by the Quebec Region for the 2009 season (pers. comm. Jean Lambert, DFO Quebec Region). The CC 2 and 3 for the Gulf Region are now considered as CC2 by Quebec region, and CC 4 for the Gulf Region is now considered as CC3-4 by Quebec Region. Consequently, observers working in both nGSL and sGSL snow crab fisheries applied the newly introduced categorization for the Quebec Region to the sGSL snow crab fisheries, which resulted in an overestimation of the percentages of newly molted crabs in landings in 2009 and 2010.

### 3.4. Analysis of newly molted crabs percentage in landings by individual observer and by observer group (Biorex Gaspé and Caraquet)

Preliminary verification of the percentage of newly molted crabs in landings indicated an overestimation for observers belonging to Biorex Gaspé compared to Biorex Caraquet. The continuously increasing trend observed in Area F is noteworthy (Fig. 4). Areas 12 and E showed an increase in the percentage in the recent years (Fig. 4). Area 19 sampled by observers from Biorex Caraquet does not show any notable increase in the percentage (Fig. 5). This trend also supports our hypothesis that the recent increase in percentage of newly molted crabs in landings was due to differences of observers' interpretations and protocols used by two different branches of Biorex (Gaspé and Caraquet).

Therefore, percentages of newly molted crabs in landings were statistically compared for the two groups of observers belonging to two different branches of the observer company. In general, none of the observers worked for the two Biorex branches within the same season for snow crab. Therefore there should be no mixture of observers trained by different DFO Regions within the same season (except for the Caraquet Branch in 2009).

Statistical tests applied to the average percentage of newly molted crabs in landings by observer groups in Area 12 within a given year since 2000 showed that all data sets did not meet the assumption of homoscedasticity of variances, and therefore a Mann-Whitney test was

applied. The difference in newly molted crabs percentages in landings between observer groups was statistically significant for all years since 2000 (Table 3). When compared within and between the two Biorex branches (Gaspé and Caraquet) for the period 2000-2007 and 2008-2010, there were also statistically significant differences for all combinations (Gaspé 2000-2007 vs 2008-2010; Caraquet 2000-2007 vs 2008-2010; Gaspé 2000-2007 vs Caraquet 2000-2007; Gaspé 2008-2010 vs Caraquet 2008-2010) (Table 4).

The same test applied to samples collected during the first two weeks of each fishing season showed statistically significant differences of newly molted crabs percentages in landings between observer groups except for 2002 (Table 5).

During the verification process, we also found that extremely high percentages of CC2 (50-75% per trip) were recorded in 2009 by several observers (7 trips) who reported to Biorex Caraquet, which resulted in an increase in percentage of newly molted crabs in 2009 for the Biorex Caraquet observer group. Verification with Biorex Caraquet revealed that these seven sampling trips were all made by samplers from Biorex Gaspé due to a shortage of observers in Biorex Caraquet at that period.

## 4.0. DISCUSSION

In the past the sGSL snow crab stocks have experienced wide biomass fluctuations during which strong recruitment waves were observed in 1991-1993, 2001-2004 and 2010-2011 where a higher percentage of newly molted crabs may be seen in the catch. This is especially true in Baie des Chaleurs where the area has been closed in season due to a high incidence of newly molted crab in the catches during the past three years (2008-2010).

The historical percentage of newly molted crabs in landings has been less than 1.6% between 1990 and 2007. The recent sudden increases in percentages of newly molted crabs in landings were the result of changes introduced in the carapace condition categorization to the nGSL fisheries before the 2009 season. A workshop on at-sea observer protocol was organized by DFO Quebec Region in the fall 2008 where a standardization of carapace categorization between at-port and at-sea samplers was proposed, of which the Gulf Region was not involved or informed. The rational for the workshop was to resolve noticeable differences between at-port and at-sea observers working in the nGSL snow crab fisheries (pers. comm. Jean Lambert). Beginning in 2009, BIOREX Gaspé had, therefore, two different carapace categorization protocols to follow, one for nGSL snow crab fisheries and another for sGSL fisheries. Hence, it seems that some observers from Biorex Gaspé applied the DFO Québec Region protocol to sGSL fisheries, which has resulted in overestimates of newly molted crabs in landings in 2009 and 2010. A slight increase in percentage of newly molted crabs in landings observed in 2008 could be due to some confusion occurring among observers working for Biorex Gaspé regarding categorization of snow crab carapace (pers. comm. Jean Lambert). The percentage of newly molted crabs in landings observed in other fishing areas (Areas 18, 25/26 and 19) in which only observers from Biorex Caraquet were deployed did not show the abrupt increase in the percentage in the last three seasons, which supports our conclusion of observer bias.

However, the significantly different percentages, albeit at low levels observed between 2000 and 2008 cannot be explained by the difference of protocol between two observer groups (due to two different sampling protocols between DFO Quebec and Gulf Regions). This could be caused by biological factors such as difference in quantity and quality (species) of epibionts, and difference in molting period. Savoie et al. (2007) concluded based on the study of fouling

community on snow crab carapace in the sGSL and on the Scotian Shelf that carapace condition criteria developed in the sGSL should not be used in the Scotian Shelf.

The past observer-data collected by Biorex Gaspé observers cannot be adjusted. We therefore consider the percentage of newly molted crabs in landings to be low (negligible) if using only the data collected by Biorex Caraquet observers for 2009 and 2010. The percentage (adjusted to landings) of newly molted crabs in landings in the 2011 season was estimated at 1.1% in Area 12 (1.3% for Biorex Caraquet and 0.7% for Biorex Gaspé).

This unfortunate situation has underlined the necessity to scrutinize data and verify the results to avoid any further introduction of observer bias. Although the percentage of newly molted crabs in landings was deemed to be negligible, the sampling should be continued because this information is necessary to verify if any component of landed crab has changed. In addition, it is increasingly important to gather physiological information including carapace conditions of snow crab every year because of climate change issues. Any change in temperature, for example, may result in a change of the molting dynamics (e.g. earlier molting, longer carapace hardening process etc.) which in turn affects the carapace classification criteria/protocol.

## 5.0. ACKNOWLEDGMENTS

We thank Jean Lambert (DFO Quebec Region, Maurice La Montagne Institute, Mont-Joli, PQ), France Henri (Biorex Gaspé) and Maurice Jean (Biorex Caraquet) for their valuable information and collaboration. Gérald Chaput and Michel Comeau (DFO Gulf Region, Gulf Fisheries Centre, Moncton NB) provided an editorial review of the manuscript.

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## 7.0. TABLES

*Table 1. Number of crab sampled and percentages of newly molted crabs (carapace conditions 1 and 2) in landings from samples collected by Biorex Gaspé and Biorex Caraquet in Area 12, 2000-2010.*

| Year | Conditions 1 and 2 Gaspé | Total measured Gaspé | Conditions 1 and 2 Caraquet | Total measured Caraquet | Total measured Gaspé and Caraquet | % non adjusted to landings | % adjusted to landings |
|---|---|---|---|---|---|---|---|
| 2000 | 424 | 12,705 | 46 | 13,963 | 26,669 | 1.76 | 1.96 |
| 2001 | 576 | 8,100 | 113 | 12,032 | 20,132 | 3.42 | 2.61 |
| 2002 | 445 | 22,313 | 213 | 31,648 | 53,962 | 1.22 | 1.03 |
| 2003 | 320 | 21,362 | 67 | 24,633 | 46,020 | 0.84 | 0.80 |
| 2004 | 723 | 26,761 | 29 | 34,567 | 61,332 | 1.23 | 1.36 |
| 2005 | 631 | 23,029 | 36 | 36,932 | 60,021 | 1.11 | 1.21 |
| 2006 | 584 | 13,769 | 31 | 23,792 | 37,561 | 1.64 | 1.65 |
| 2007 | 658 | 13,635 | 17 | 22,811 | 36,446 | 1.85 | 2.26 |
| 2008 | 1,729 | 12,775 | 149 | 21,563 | 34,338 | 5.47 | 6.37 |
| 2009 | 5,035 | 17,604 | 1,361 | 25,138 | 42,742 | 14.96 | 15.86 |
| 2010 | 1,673 | 7,117 | 96 | 10,001 | 17,118 | 10.33 | 10.96 |

*Table 2. Comparison of criteria used for categorization of carapace conditions of snow crab in the southwestern Gulf of St. Lawrence (Areas 12, E and F) and in the northern Gulf of St. Lawrence (12A, 12B, 12C, 17, 16, 16A, 15, 14 and 13). Criteria for conditions 1, 4 and 5 are identical between the two Regions, but conditions 2 and 3 were different (differences between Regions are in bold). (see Hébert et al. 2012 for the detail of carapace color and other features corresponding to each carapace condition in the sGSL).*

| Carapace condition | | Identification criteria |
|---|---|---|
| Condition 1 | | The carapace is light brown dorsally and pinkish-white ventrally. The exoskeleton is soft and very clean. The claws are clean, iridescent and are easily broken under thumb pressure. The hemolymph is visible. The carapace has neither scars nor epibionts. |
| Condition 2. | Southern Gulf | The carapace is light brown dorsally and **white** ventrally. The exoskeleton is hard and very clean. The claw can be broken under thumb pressure, but with difficulty. The claws are iridescent and shiny. The **carapace has no epizoites.** |
| | Northern Gulf | The carapace is light brown dorsally and **pinkish-white or cream** ventrally. The exoskeleton is hard and very clean. The claws are clean, iridescent and hard. **Occasional scars on the carapace but minor, if any. Epibionts are rarely present on the carapace.** |
| Condition 3 | Southern Gulf | The carapace is pinkish-brown dorsally and **whitish-beige** ventrally. The exoskeleton is hard and clean. The claws are hard and may have some iridescence. **The carapace has very few scars and may have small epizoites (white marks). Some epibionts (moss) may be present.** |
| | Northern Gulf | The carapace is pinkish-brown dorsally **and yellowish brown ventrally**. The exoskeleton is hard and clean. The claws are hard, may have some iridescence and **spines are showing signs of wear. Scars are visible and small to medium epibionts are usually present.** |
| Condition 4 | | The dorsal surface is brown dorsally and yellowish brown with black spots ventrally. The exoskeleton is hard and dirty. The claws are hard, lack iridescence and spines are dull. The crab is dirty, has several scars and has numerous large epibionts |
| Condition 5 | | The carapace is dark brown dorsally and yellowish-brown ventrally. The carapace is soft and very dirty. The claws are also soft, blackened and the spines are very dull. The softening of the exoskeleton (decalcification) is especially noticeable in leg articulations. The crab has large amounts of scars and organisms on its carapace and is heavily covered by epibionts. |

*Table 3. Percentages of newly molted crabs adjusted to landings in at-port sampling in Area 12 by two groups of observers (Biorex Gaspé and Biorex Caraquet) and results of statistical comparisons between groups of observer within a given season (F-test for homogeneity of variances and Mann-Whitney for difference of means).*

| Year | Biorex | Number of boats sampled | Standardized mean (%) | F test | P-Value | Mann-W test | P-Value |
|---|---|---|---|---|---|---|---|
| 2000 | Caraquet | 265 | 0.24 | 0.031 | <0.0001 | -6.649 | <0.0001 |
| 2000 | Gaspé | 183 | 1.71 | | | | |
| 2001 | Caraquet | 259 | 0.57 | 0.189 | <0.0001 | -7.507 | <0.0001 |
| 2001 | Gaspé | 168 | 2.04 | | | | |
| 2002 | Caraquet | 628 | 0.31 | 0.150 | <0.0001 | -3.851 | 0.0001 |
| 2002 | Gaspé | 438 | 0.72 | | | | |
| 2003 | Caraquet | 407 | 0.22 | 0.703 | 0.0009 | -6.327 | <0.0001 |
| 2003 | Gaspé | 322 | 0.58 | | | | |
| 2004 | Caraquet | 627 | 0.04 | 0.002 | <0.0001 | -9.386 | <0.0001 |
| 2004 | Gaspé | 443 | 1.32 | | | | |
| 2005 | Caraquet | 667 | 0.07 | 0.007 | <0.0001 | -11.253 | <0.0001 |
| 2005 | Gaspé | 364 | 1.14 | | | | |
| 2006 | Caraquet | 482 | 0.13 | 0.049 | <0.0001 | -10.107 | <0.0001 |
| 2006 | Gaspé | 285 | 1.52 | | | | |
| 2007 | Caraquet | 420 | 0.26 | 0.277 | <0.0001 | -12.061 | <0.0001 |
| 2007 | Gaspé | 263 | 2.00 | | | | |
| 2008 | Caraquet | 395 | 0.38 | 0.011 | <0.0001 | -14.570 | <0.0001 |
| 2008 | Gaspé | 229 | 6.00 | | | | |
| 2009 | Caraquet | 436 | 2.77* | 0.138 | <0.0001 | -16.301 | <0.0001 |
| 2009 | Gaspé | 300 | 13.09 | | | | |
| 2010 | Caraquet | 179 | 0.83 | 0.012 | <0.0001 | -11.945 | <0.0001 |
| 2010 | Gaspé | 104 | 10.14 | | | | |

* 0.130% after elimination of data collected by Biorex Gaspé observers that temporarily worked for Biorex Caraquet.

*Table 4. Results of comparison of percentages of newly molted crabs adjusted to landings in at-port samples in Area 12 between two periods (2000-2007 and 2008-2010), and between and among the groups of observers (Biorex Gaspé and Biorex Caraquet,) between two periods (2000-2007 and 2008-2010), (F-test for homogeneity of variances and Mann-Whitney test for difference of means).*

| Year | BIOREX observer group | Number of boats sampled | Standardized Mean (%) | F test | P-Value | Mann-W test | P-Value |
|---|---|---|---|---|---|---|---|
| 2000-2007 | Gaspé | 2466 | 3.227 | 9.075 | <0.0001 | -21.726 | <0.0001 |
| 2008-2010 | Gaspé | 633 | 24.046 | | | | |
| 2000-2007 | Caraquet | 3755 | 0.313 | 0.052 | <0.0001 | -3.709 | 0.0002 |
| 2008-2010 | Caraquet | 1010 | 2.688 | | | | |
| 2000-2007 | Caraquet | 3755 | 0.313 | 0.066 | <0.0001 | -13.763 | <0.0001 |
| 2000-2007 | Gaspé | 2466 | 3.227 | | | | |
| 2008-2010 | Caraquet | 1010 | 2.688 | 0.141 | <0.0001 | -21.324 | <0.0001 |
| 2008-2010 | Gaspé | 633 | 24.046 | | | | |

*Table 5. Percentages of newly molted crabs adjusted to landings in at-port samples in Area 12 for the first two weeks of the season by two groups of observers (Biorex Gaspé, Québec and Biorex Caraquet, New Brunswick) and results of statistical comparisons (F-test for homogeneity of variances and Mann-Whitney and T-test for difference of means).*

| Year | Observer group | Number of boats sampled | Standardized Mean (%) | F test | P-Value | Mann-W test | T-test | P-Value |
|---|---|---|---|---|---|---|---|---|
| 2000 | Gulf | 64 | 0.12 | 0.037 | <0.0001 | -3.747 | | 0.0002 |
| 2000 | Québec | 33 | 0.67 | | | | | |
| 2001 | Gulf | 81 | 0.35 | 0.402 | 0.0004 | -4.308 | | <0.0001 |
| 2001 | Québec | 54 | 0.75 | | | | | |
| 2002 | Gulf | 130 | 0.18 | 0.120 | <0.0001 | -1.676 | | 0.0938 |
| 2002 | Québec | 62 | 0.38 | | | | | |
| 2003 | Gulf | 201 | 0.20 | 0.736 | 0.0613 | | -2.473 | 0.0139 |
| 2003 | Québec | 121 | 0.39 | | | | | |
| 2004 | Gulf | 150 | 0.01 | 0.003 | <0.0001 | -7.170 | | <0.0001 |
| 2004 | Québec | 76 | 0.40 | | | | | |
| 2005 | Gulf | 179 | 0.03 | 0.003 | <0.0001 | -4.862 | | <0.0001 |
| 2005 | Québec | 66 | 0.51 | | | | | |
| 2006 | Gulf | 96 | 0.09 | 0.497 | 0.0020 | -4.167 | | <0.0001 |
| 2006 | Québec | 70 | 0.29 | | | | | |
| 2007 | Gulf | 144 | 0.03 | 0.002 | <0.0001 | -8.173 | | <0.0001 |
| 2007 | Québec | 88 | 1.02 | | | | | |
| 2008 | Gulf | 103 | 0.22 | 0.019 | <0.0001 | -7.033 | | <0.0001 |
| 2008 | Québec | 64 | 2.10 | | | | | |
| 2009 | Gulf | 107 | 0.50 | 0.076 | <0.0001 | -9.853 | | <0.0001 |
| 2009 | Québec | 117 | 6.47 | | | | | |
| 2010 | Gulf | 97 | 0.60 | 0.027 | <0.0001 | -9.220 | | <0.0001 |
| 2010 | Québec | 49 | 5.70 | | | | | |

## 8.0. FIGURES

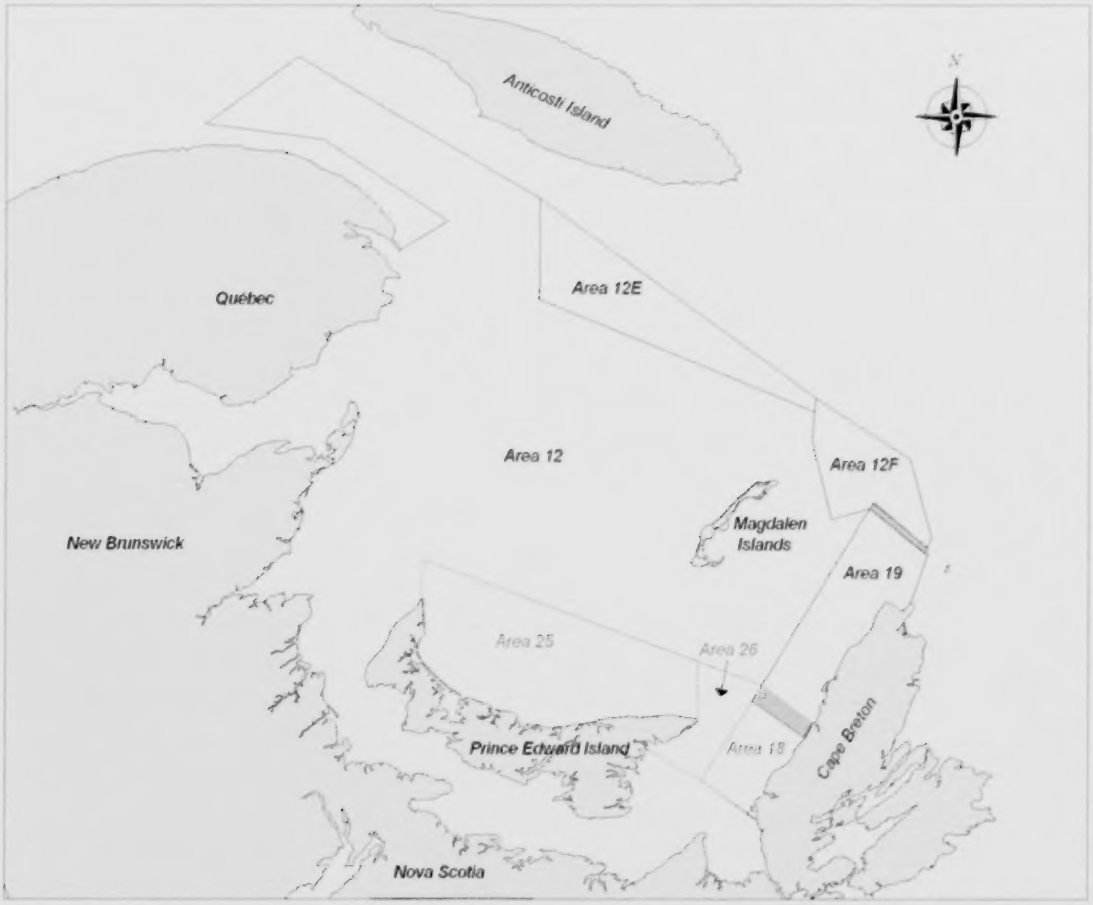


*Figure 1. Map of the southern Gulf of St. Lawrence showing the current snow crab fishing Areas (in blue), management buffer zones (shaded) and old fishing Areas 18 and 25/26 (in green) prior to amalgamation into Area 12 in 1999.*

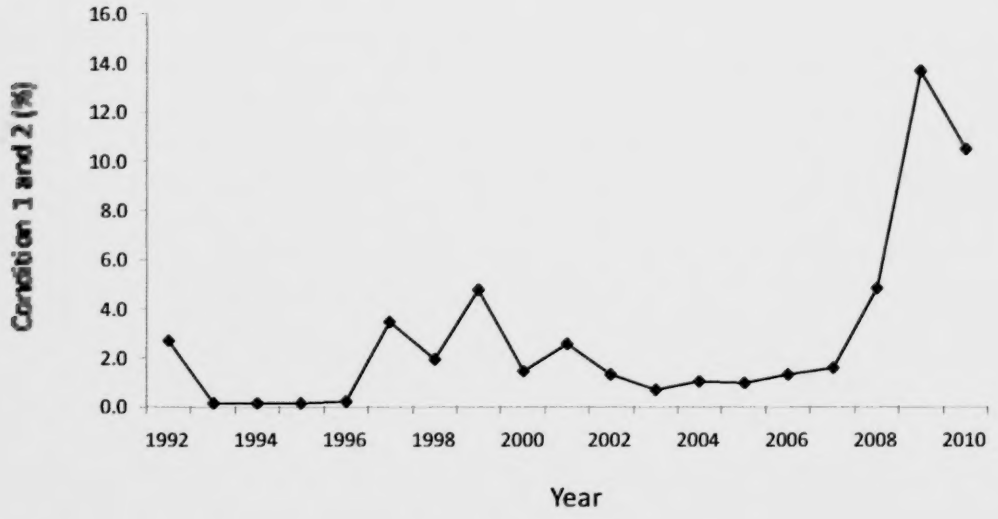


*Figure 2. Percentage of commercial-sized adult males with carapace conditions 1 and 2 in landings (modified from Hébert et al. 2011).*

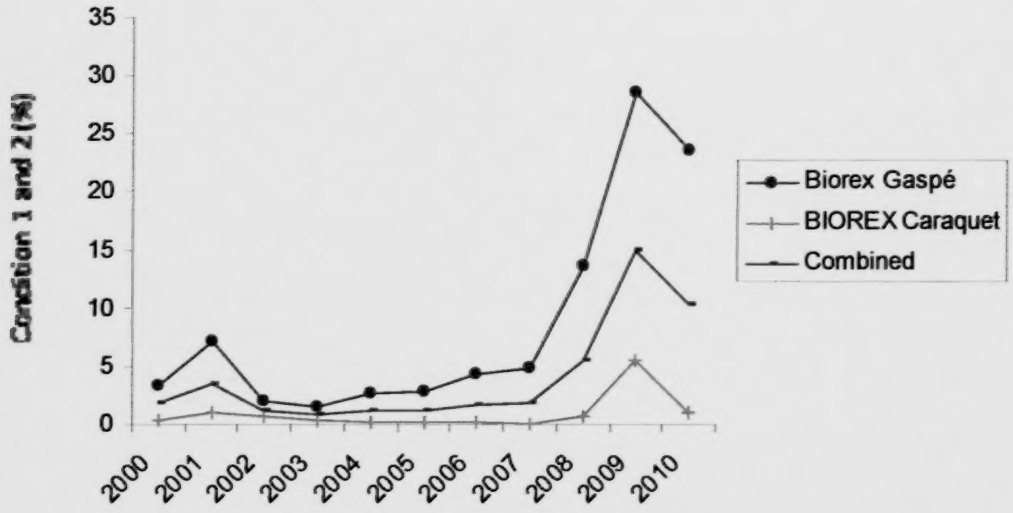


*Figure 3. Percentage (adjusted to landings) of commercial-sized adult males with carapace conditions 1 and 2 in landings by observer group.*

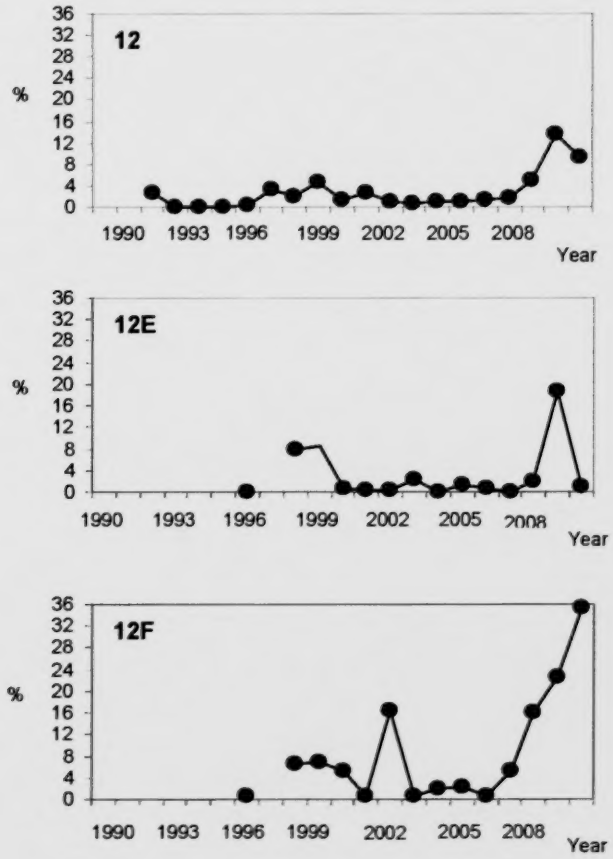


*Figure 4. Percentage (adjusted to landings) of commercial-sized adult males with carapace conditions 1 and 2 in landings in Areas 12 (traditional fleet), 12E, and 12F. At-port sampling was done by Biorex Gaspé and Biorex Caraquet observers.*

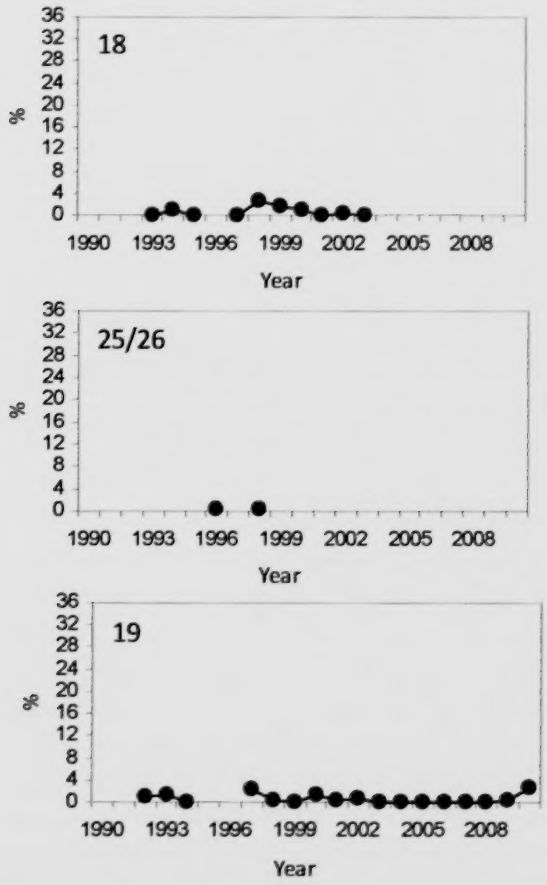


*Figure 5. Percentage (adjusted to landings) of commercial-sized adult males with carapace conditions 1 and 2 in landings in Areas 18 (before amalgamation into Area 12 in 2003), Area 25/26 (before amalgamation into Area 12 in 1999), and 19. At-port sampling was performed by Biorex Caraquet observers only.*